

Short Communication

A STUDY ON EFFECT OF MOBILE PHONE RADIATION ON HUMAN HEALTH

Rajdeep Mitra^{*}, Milan Mazumder, Koushik Pal¹, Subasish Jana²

ABSTRACT: A study was conducted in and around North-East Kolkata, West Bengal, India to find out the effect of Electro-Magnetic Radiation emitted by Global System for Mobile (GSM) and Code Division Multiple Access (CDMA) Mobile Phones on blood pressure, heart rate, pulse rate, respiration rate and body temperature on 20 healthy people (10 male and 10 female), age group within 21 to 60 years. In silent and calling mode, rapid and arrhythmic heart rate, rapid and irregular pulse rate were noted in 5% male in the age group of 21–40 years after 30 minutes exposure, when handset placed in ear closure to brain. Same observations were found only in 5% male after 15 minutes exposure and in 5% female &10% male after 30 minutes exposure,when handset placed on chest closure to heart in the age group of 41–60 years.

Key words: Electro-magnetic radiation, Mobile phone, Blood pressure, Heart rate, Pulse rate, Respiration rate, Body temperature, Arrhythmia.

The development and application of devices that emit radio-frequency radiation have significantly increased the quality of life throughout the world (Ayeni *et al.*, 2011). The rapid increase in the use of mobile phones (MPs) in recent years has raised the problem of health risk connected with high-frequency electromagnetic fields, remain (Ahamed *et al.*,

2008, Sainiand Pandey 2013). Electromagnetic radiofrequency emitted from MP, which was liable for causing a number of negative health effects in the form of influencing on the heart and circulatory system (Fatma *et al.*, 2011). Oliver *et al.* (2011) reported that high-frequency electromagnetic fields of MP is associated with health risks. Even electromagnetic fields which

Department of Electronics and Communication Engineering, Regent Education and Research Foundation, Barrackpore, Kolkata – 700121, West Bengal, India.

**Corresponding author. e - mail: rajdeepmitra01@gmail.com*

¹ Assistant Professor, Department of Electronics and Communication Engineering, Gurunanak Institute of Technology, Kolkata, West Bengal, India.

² Medical Officer, Swastha Bhavan, Kolkata, India.

are emitted by cellular phones interfere with the work of cardiac pacemakers and other implantable medical devices (Altamura 1997, Barbaro 1999). The increased use of wireless mobile phones worldwide has focused interest on its possible side effects, and the potential health impacts (Hoskote *et al.*, 2008). Mobile phones are usually held in the close proximity to the human heart therefore exposure to radiation is high (Ayeni *et al.*, 2011). Objective of the study was to find out the actual effect of mobile phone radiation on human health in different parameter in different age group and sex. This paper investigated the effect of GSM and CDMA mobile phone radiation on human health measuring any changes of Blood pressure (BP), Heart rate (HR), Pulse rate (PR), Respiration rate (RR) and Body temperature (BT).

Study design

Two MP with Global System for Mobile (GSM) and Code Division Multiple Access (CDMA) dual Subscriber Identity Module (SIM)(Micromax, Model number - GC222 and Q35), Digital fully automatic Blood Pressure monitor (Dr. Morepen, Model number - BP 06i), Sphygmomanometer (Doctor, Made in Japan), Stethoscope (H. Das, Made in India), Thermometer (Hicks, Made in India), Wrist watch (Titan Quartz, Made in India) were used in this study.

The study was made for the period from October, 2013 to September, 2014 in North-East Kolkata, West Bengal, India. Verbal consent has been taken from all the adult healthy peoples, who have been participated whole heatedly in the study. Twenty healthy peoples, age group within 21 to 40 years (05 male and 05 female) and 41 to 60 years (05 male and 05 female)

with 52 – 76 kgs body weight were taken in the study. A set of participants were selected from the population, which is less in number (size)(Kadam and Bhalerao 2010). Systolic-diastolic BP, HR, PR, RR and BT were recorded before using MP and after 15 and 30 minutes of exposure. Participants in the study were holding MP by hand in ear closure to brain and on chest closure to heart in silent and calling mode (Aghav 2013, Saini and Pandey 2013).

Digital BP monitor (Dr. Morepen, Model number - BP 06i), sphygmomanometer (Doctor, Made in Japan) and stethoscope (H. Das, Made in India) were used for measuring systolic-diastolic BP. HR were measured by using stethoscope by listening to the heart beat directly (auscultation). RR were measured using stethoscope and by counting up-down of the chest during breathing. PR were measured in the wrist (on radial artery) pressing by index and middle figures, counting it per minute. BT was measured by using standard mercury-in-glass thermometer(Hicks, Made in India) under tongue (orally). Time was recorded by using wrist watch (Titan Quartz, Made in India). The study was made during evening in fully resting stage in a sitting position, atleast 2 hours before and after taking any food, avoiding talking, any type of sound, physical and mental stress. No electronics devices (including any other MP) were kept within the same room of this study to avoid any possible interference. All the data were recorded.

Finding of the study

Systolic-diastolic BP, HR, PR, RR and BT were recorded before using MP in 20 healthy people age group within 21 to 40 years (05 male and 05 female) and 41 to 60 years (05 male and 05 female). The normal ranges

for a person's vital signs like BP, HR, PR, RR, BT vary with age, weight, gender, and overall health(http://prohealthsys.com/site/resources/assessment/physical-assessment/vital-signs/vital_signs_table). During study, all the parameters were found in normal range before exposure.

In silent and calling mode, no other changes noted except rapid and arrhythmic HR, rapid and irregular PR in one (5%) male after 30 minutes exposure, when handset placed in ear closure to brain in the age group of 21 – 40 years. Same changes we observed only in one (5%) male after 15 minutes exposure and in one (5%) female and two (10%) male after 30 minutes exposure, when handset placed on chest closure to heart in the age group of 41–60 years. All data statistically analyzed and found insignificant for the effect of MP exposure in ear closure to brain and on chest closure to heart in relation to sex and age group.

It has been observed that HR & PR increased 11 per minutes after exposure of MP radiation in ear closure to brain in 5% male, but not in female. It increased 16 per minutes after 15 minutes exposure on chest closure to heart in 5% male, but not in female. But after 30 minutes exposure on chest closure to heart, both HR & PR increased 14 per minutes in 5% female and 18 - 19 per minutes in 10 % male along . Both HR & PR increased (16 and 19) in an individual after 15 and 30 minutes exposure on chest closure to heart (Table 1). HR & PR were found arrhythmic and irregular respectively during close monitoring after MP exposure in same individuals.

Aghav *et al.* (2013) reported that a cell phone transmits 1 to 2 watt of power in the frequency range of 824 to 849 MHz(CDMA), 890 to 915 MHz(GSM900), 1710 to 1780 MHz(GSM1800). Hung-Wen Chiu (2010)

reported that MPs are low power radio devices, which work on electro-magnetic fields (EMFs), in the frequency range of 900 - 1800 MHz. Significant change during high RFR exposure as mobile phone emit power highest during calling mode, rest in other conditions the low RFR exposure (Saini and Pandey 2013). Alhusseiny *et al.*(2012) in a study showed that the radiofrequency of cell phone interferes with the cardiac conduction. Autonomic control of the heart was altered in exposure to radio-frequency electromagnetic field (RF-EMF) from mobile phones (Carpenter and Sage 2008). Rezk *et al.*(2008) reported pregnant women exposed to EMF emitted by mobile phones on telephone-dialing mode for 10 minutes a day during pregnancy and after birth had babies with statistically significant increases in fetal and neonatal heart rate. Wargo *et al.* (2012) reported that exposure to electromagnetic radiation emitted from cellular devices varies by model of phone, antenna configuration, and signal strength. Weak signal strength leads to higher levels of exposure, as the device routinely seeks a stronger signal.

Lindholm *et al.* (2011) monitored local cerebral blood flow during exposure to GSM mobile phone radiation in a teenager group (14 – 15 years old) by measuring electrocardiogram (ECG), blood pressure, temperature simultaneously and found there were no significant changes during the short term RF-EMFs exposure. Choi *et al.* (2014) found no effects in teenagers or adults as a result of 32 min exposure to RF radiation emitted by WCDMA mobile phones. But in this study, people (5% female and 10% male) influenced by short term (upto 30 minutes) RF-EMFs exposure of MP in the age group of 41 – 60 years and in 5% male after 15 minutes exposure in the age group of 20 – 40 years. An

A study on acute effect of mobile phone radiation on human health.

Age Group (In Years)	Sex	Initial Readings	Blood Pressure (BP) Cystostatic / Diastolic						Heart Rate (HR) / minute						Pulse Rate (PR) / minute						Respiration Rate (RR) / minute						Body Temperature (BT) °F					
			BP (Extr)			AE (Chest)			BE (Extr)			AE (Chest)			BE (Extr)			AE (Bar)			BE (Extr)			AE (Bar)			BE (Extr)					
			BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)	BP	AE	(Extr)			
21 - 40	M-1	M-1	124 /78	124 /82	124 /82	124 /122	124 /122	124 /122	124 /78	124 /78	124 /78	124 /120	124 /120	124 /120	124 /76	124 /76	124 /76	124 /116	124 /116	124 /116	124 /120	124 /120	124 /120	124 /76	124 /76	124 /76	124 /116	124 /116	124 /116			
	M-2	M-2	122 /78	122 /82	122 /82	122 /122	122 /122	122 /122	122 /78	122 /78	122 /78	122 /120	122 /120	122 /120	122 /76	122 /76	122 /76	122 /116	122 /116	122 /116	122 /120	122 /120	122 /120	122 /76	122 /76	122 /76	122 /116	122 /116	122 /116			
	M-3	M-3	120 /76	120 /80	120 /80	120 /120	120 /120	120 /120	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116	120 /120	120 /120	120 /120	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116			
	M-4	M-4	120 /80	120 /84	120 /84	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116			
	M-5	M-5	126 /84	126 /84	126 /84	126 /126	126 /126	126 /126	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84			
	F-1	F-1	116 /76	116 /80	116 /80	116 /120	116 /120	116 /120	116 /76	116 /76	116 /76	116 /116	116 /116	116 /116	116 /76	116 /76	116 /76	116 /116	116 /116	116 /116	116 /120	116 /120	116 /120	116 /76	116 /76	116 /76	116 /116	116 /116	116 /116			
	M-6	M-6	120 /76	120 /82	120 /82	120 /120	120 /120	120 /120	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116	120 /120	120 /120	120 /120	120 /76	120 /76	120 /76	120 /116	120 /116	120 /116			
	M-7	M-7	118 /80	118 /84	118 /84	118 /122	118 /122	118 /122	118 /80	118 /80	118 /80	118 /116	118 /116	118 /116	118 /80	118 /80	118 /80	118 /116	118 /116	118 /116	118 /122	118 /122	118 /122	118 /80	118 /80	118 /80	118 /116	118 /116	118 /116			
	M-8	M-8	116 /80	116 /84	116 /84	116 /120	116 /120	116 /120	116 /80	116 /80	116 /80	116 /116	116 /116	116 /116	116 /80	116 /80	116 /80	116 /116	116 /116	116 /116	116 /120	116 /120	116 /120	116 /80	116 /80	116 /80	116 /116	116 /116	116 /116			
	F-2	F-2	112 /76	112 /82	112 /82	112 /122	112 /122	112 /122	112 /76	112 /76	112 /76	112 /116	112 /116	112 /116	112 /76	112 /76	112 /76	112 /116	112 /116	112 /116	112 /122	112 /122	112 /122	112 /76	112 /76	112 /76	112 /116	112 /116	112 /116			
41 - 60	M-9	M-9	126 /82	126 /86	126 /86	126 /122	126 /122	126 /122	126 /82	126 /82	126 /82	126 /120	126 /120	126 /120	126 /82	126 /82	126 /82	126 /120	126 /120	126 /120	126 /82	126 /82	126 /82	126 /120	126 /120	126 /120	126 /82	126 /82	126 /82			
	M-10	M-10	122 /82	122 /82	122 /82	122 /122	122 /122	122 /122	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82			
	F-3	F-3	124 /78	124 /82	124 /82	124 /122	124 /122	124 /122	124 /78	124 /78	124 /78	124 /120	124 /120	124 /120	124 /78	124 /78	124 /78	124 /120	124 /120	124 /120	124 /78	124 /78	124 /78	124 /120	124 /120	124 /120	124 /78	124 /78	124 /78			
	M-6	M-6	120 /78	120 /82	120 /82	120 /122	120 /122	120 /122	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116	120 /122	120 /122	120 /122	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116			
	F-7	F-7	120 /80	120 /84	120 /84	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116			
	M-8	M-8	126 /84	126 /84	126 /84	126 /122	126 /122	126 /122	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84			
	M-9	M-9	122 /82	122 /82	122 /82	122 /122	122 /122	122 /122	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82	122 /120	122 /120	122 /120	122 /82	122 /82	122 /82			
	F-10	F-10	120 /78	120 /82	120 /82	120 /122	120 /122	120 /122	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116	120 /122	120 /122	120 /122	120 /78	120 /78	120 /78	120 /116	120 /116	120 /116			
	F-11	F-11	120 /80	120 /84	120 /84	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116	120 /120	120 /120	120 /120	120 /80	120 /80	120 /80	120 /116	120 /116	120 /116			
	M-12	M-12	126 /84	126 /84	126 /84	126 /122	126 /122	126 /122	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84	126 /120	126 /120	126 /120	126 /84	126 /84	126 /84			

BE = Before Exposure ; **AE** = After Exposure ; **15 M** = 15 minutes ; **30 M** = 30 minutes ; ***** = Rapid & arrhythmic; ****** = Rapid & irregular

international team of researchers recently discovered that in some individuals, the 2.4 GHz pulsed signals emitted by a cordless phone system produce significant disruptions in cardiac rhythm.

Ahamed *et al.* (2008) in a study found that the neurological effect of electromagnetic fields radiated from MPs, as heart rate is modulated by the autonomic nervous system and MP has caused changes in heart rate varied with its position. Huber *et al.* (2003) found a mild relationship between MP usage and heart rate variability(HRV) parameters. However, this relationship has not been supported by other study (Barker *et al.*, 2007). Effect of electromagnetic fields radiated from MPs, by studies on HRV found that increase the parameter, when MP is kept close to the chest and a decrease when kept close to the head. MP has caused changes in HRV indices and the change varied with its position (Ahamed *et al.*, 2008).Mobile phone radiation has caused change in HRV parameters and it varied with radiation level. The study indicates that HRV increases with statistical significance, when mobile phone sited near chest in calling mode (Saini and Pandey 2013). Anytime the power is turned on, cell phones emit electromagnetic radiation – even in stand-by mode and regardless if carried on belts, in pockets or purses, expose other areas of the body to harmful electromagnetic fields radiation. Cellphones emit electromagnetic radiation from its antenna, as well as from the circuitry and battery – all of which can cause harmful biological effects. Most health care institutions initially responded to the problem of cellular phone-related EMI with an institution wide ban on cellular phone use (Lapinsky and Easty 2006). CDMA-type MPs and GSM - type MPs

differ in their operating frequency range and electromagnetic field output power. Thus, the effects of CDMA-type MPs on humans may differ from those of GSM-type MPs (Chu *et al.*, 2011). But in our study, the effect of MP radiation were found similar in both handset used dual SIM (GSM + CDMA).

Aghav *et al.* (2013) observed that for male of age group 20 – 30, Rc varies from 2.81% to 6.21% showing significant change of 6.4% bmp in heart rate in silent mode. This is because in silent mode all the signals are totally electromagnetic radiation, which is very harmful to our heart and in other modes, some signal is utilised for vibration or ringing. A recently published randomized double-blinded study also did not find any effect of mobile phone radiation on blood pressure (Tahvanainen *et al.*, 2004), which corroborate with our findings.

In this study, BT was measured before and after exposure of EMR from MP in the ear closure to brain to monitor the effect on thermo-regulatory centre. Local temperature elevation in the area of MP use has been noted in several studies (Anderson and Rowley 2007, Acar *et al.*, 2009).All the usersreported heating of tissues near ear after 30 minutes exposure of MP in silent and calling mode due specific absorption rate (SAR) but no changes observed on BT. Chia *et al.*(2000) reported the adverse effects of these important communications tools with sensations of burning or warmth around the ear and headache. It is advisable that people of age 40 years and above should avoid keeping mobile phones close to the heart (Ayeni *et al.*, 2011).Some people have multiple chemical sensitivity or react to pollen, mold, and certain types of food, a growing population is becoming “sensitive” to electromagnetic radiation and it is difficult to estimate the percentage of the population that has electro-

hypersensitive(Havas 2013), extensive study required before making any conclusion. Further experimentation is needed to conduct on more number of subjects with different Radio-Frequency radiation exposure levels.

ACKNOWLEDGEMENT

Authors are thankful to the Vice-Chancellor, West Bengal University of Health Sciences, Director of Medical Education & Research, Govt. of West Bengal, India and all participants of this study.

REFERENCES

Acar GO, Yener HM, Savrun FK, Kalkan T, Bayrak I, Enver O (2009) Thermal effects of mobile phones on facial nerves and surrounding soft tissue. *The Laryngoscope* 119(3): 559-562.

Aghav Sakharam D (2013) Study of Radiation exposure due to mobile towers and mobile phones. *Review Res* 3(3): 1-6.

Aghav SD, Yande JV, Tambade PS (2013) Study of effects of mobile phone and mobile tower radiations. *Indian Streams Res J* 1-7.

Ahamed VIT, Karthick NG, Joseph PK (2008) Effect of mobile phone radiation on heart rate variability. *Comput Biol Med* 38(6): 709-712.

Alhusseiny AH, Al-Nimer MS, Majeed AD (2012) Electromagnetic Energy Radiated from Mobile Phone Alters Electrocardiographic Records of Patients with Ischemic Heart Disease. *Ann Med Health Sci Res* 2(2): 146-151.

Altamura G, Toscano S, Gentilucci G, Ammirati F (1997) Influence of digital and analogue cellular telephones on implanted pacemakers. *Eur Heart* 18: 1632-1641.

Anderson V, Rowley J (2007) Measurements of skin surface temperature during mobile phone use. *Bioelectromagnetics* 28(2):159-162.

Ayeni AA, Braimoh KT, Ayeni OB (2011) Effect of GSM Phone Radiation on Human Pulse Rate (Heartbeat Rate). *J Emerging Trends Computing Inform Sci* 2(11): 580-587. <http://www.cisjournal.org>

Barbaro V, Bartolini P, Donato A, Militello C (1999) Electromagnetic interference of analog cellular telephones with pacemakers: *in vitro* and *in vivo* studies. *Pace* 22: 626-634.

Barker AT, Jackson PR, Parry H, Coulton LA, Cook GG, Wood SM (2007) The effect of GSM and TETRA mobile handset signals on blood pressure, catechol levels and heart rate variability. *Bioelectromagnetics* 28: 433-438.

Carpenter DO, Sage C (2008) Setting prudent public health policy for electromagnetic field exposures. *Rev Environ Health* 23(2): 91-117.

Chia SE, Chia HP, Tan JS (2000) Prevalence of headache among handheld cellular telephone users in Singapore: a community. *Environ Health Perspect* 108: 1059-1062.

Choi SooBeom, Kwon Min Kyung, Chung Jai Won, Park Jee Soo, Chung Kil Soo, Kim Deok Won (2014) Effects of short-term radiation emitted by WCDMA mobile phones on teenagers and adults. *BMC Public Health* 14: 438.

Chu Min Kyung, Song HoonGeun, Kim Chulho, Lee Byung Chul (2011) Clinical features of headache associated with mobile phone use: a cross-sectional study in university students. *BMC Neurology* 11: 115- 121. [<http://www.biomedcentral.com/1471-2377/11/115>]

Fatma A, Mohamed Azza A, Ahmed Bataa MA, El-Kafoury, Noha N Lasheen (2011) Study of the Cardiovascular Effects of Exposure to Electromagnetic Field. *Life Sci J* 8(1): 260.

Havas Magda (2013) Radiation from wireless technology affects the blood, the heart and the autonomic nervous system. *Rev Environ Health* 28(2-3): 75–84.

Huber R, Schuderer J, Graf T, Jutz K, Borbely AA, Kuster N, et al. (2003) Radio frequency electromagnetic field exposure in humans : Estimation of SAR distribution in the brain, effects on sleep and heart rate. *Bioelectromagnetics* 24: 262-276.

Hung-Wen chiu (2010) Frequency-domain heart rate variability analysis performed by digital filters Tsung-Chieh Lee1, Computing Cardiology 37: 589-592.

Hoskote SS, Kapdi M, Joshi SR (2008) An Epidemiological Review of Mobile Telephones and Cancer. *JAPI* 56: 980-984.

Kadam Prashant and Bhalerao Supriya (2010) Sample size calculation. *Int J Ayurveda Res* 1(1): 55–57.

Lapinsky E Stephen and Easty C Anthony (2006) Electromagnetic interference in critical care. *J Critical Care* 21: 267– 270.

Lindholm H, Alanko T, Rintamäki H, Kännälä S, Toivonen T, Sistonen H, Tiikkaja M, Halonen J, Mäkinen T, Hietanen M (2011) Thermal effects of mobile phone RF fields on children: a provocation study. *Prog Biophys Mol Biol* 107: 399-403.

Oliver Faust, AcharyaU. Rajendra, Nergui Myagmarbayar, GhistaDhanjoo N, Chattopadhyay Subhagata, Paul Joseph, Ahamed Thajudin, Tay Dorothy(2011) Effects of mobile phone radiation on cardiac health. *J Mech Med Biol* 11: 1241

Rezk AY, Abdulqawi K, Mustafa RM, et al. (2008) Fetal and neonatal responses following maternal exposure to mobile phones. *Saudi Med J* 29(2): 218-223.

Saini B S, PandeyAnukul (2013) Effect of mobile phone and BTS radiation on heart rate variability. *IJRET* 2 (4): 662– 666.

Tahvanainen K, Nino J, Halonen P, Kuusela T, Laitinen T, Lan-simies E, Hartikainen J, Hietanen M, Lindholm H (2004) Cellular phone use does not acutely affect blood pressure or heart rate of humans. *Bioelectromagnetics* 25: 73–83.

Wargo John, Taylor Hugh S, Alderman Nancy, Wargo Linda, Bradley Jane M, Addiss Susan (2012) Cell phones – Technology, Exposures, Health effects. EHHI. North Haven. 1-72.

Cite this article as: Mitra R, Mazumder M, Pal K, Jana S (2014) A study on effect of mobile phone radiation on human health. *Explor Anim Med Res* 4(2): 246-252.